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# Doubly Linked List

Here is *yet* another implementation of the list abstract data type, using *doubly linked list*.

﻿using System;  
using System.Collections;  
using System.Collections.Generic;  
  
public class DLList<T> : ICollection<T>  
{  
 private Cell head;  
 private Cell tail;  
  
 public DLList()  
 {  
 head = null;  
 tail = null;  
 }  
  
 private class Cell  
 {  
 public T Data { get; set; }  
 public Cell Next { get; set; }  
 public Cell Previous { get; set; }  
  
 public Cell(  
 T dataP = default(T),  
 Cell previousP = null,  
 Cell nextP = null  
 ) // We provide default values  
 {  
 Data = dataP;  
 Previous = previousP;  
 Next = nextP;  
 }  
 }  
  
 // Empty  
 public bool IsEmpty()  
 {  
 return head == null;  
 }  
  
 // Add "to the right",  
 // at the end of the list.  
 public void Add(T value)  
 {  
 if (IsReadOnly)  
 {  
 throw new InvalidOperationException(  
 "List is read-only."  
 );  
 }  
 if (head == null)  
 {  
 head = new Cell(value, null, null);  
 tail = head;  
 }  
 else  
 {  
 tail.Next = new Cell(value, tail, null);  
 tail = tail.Next;  
 }  
 }  
  
 public void Clear()  
 {  
 head = null;  
 tail = null;  
 }  
  
 public bool Contains(T value)  
 {  
 bool found = false;  
 Cell cCell = head;  
 while (cCell != null && !found)  
 {  
 if (cCell.Data.Equals(value))  
 {  
 found = true;  
 }  
 cCell = cCell.Next;  
 }  
 return found;  
 }  
  
 // Copies the elements of the ICollection to an Array, starting at a particular Array index.  
 public void CopyTo(T[] array, int arrayIndex)  
 {  
 if (array == null)  
 throw new ArgumentNullException(  
 "The array cannot be null."  
 );  
 if (arrayIndex < 0)  
 throw new ArgumentOutOfRangeException(  
 "The starting array index cannot be negative."  
 );  
 if (Count > array.Length - arrayIndex)  
 throw new ArgumentException(  
 "The destination array has fewer elements than the collection."  
 );  
  
 Cell cCell = head;  
 int i = 0; // keeping track of how many elements were copied.  
 while (cCell != null)  
 {  
 array[i + arrayIndex] = cCell.Data;  
 i++;  
 cCell = cCell.Next;  
 }  
 }  
  
 public bool Remove(T value)  
 {  
 if (IsReadOnly)  
 {  
 throw new InvalidOperationException(  
 "List is read-only"  
 );  
 }  
 bool removed = false;  
 if (!IsEmpty())  
 {  
 // If the value we are looking for  
 // is held by head  
 if (head.Data.Equals(value))  
 {  
 head = head.Next;  
 // If there was more than one  
 // cell in our list  
 if (head != null)  
 {  
 // We delete the reference  
 // to the node  
 // we want to remove.  
 head.Previous = null;  
 }  
 else  
 {  
 // Since there was only one cell in our list,  
 // the tail needs to be updated.  
 tail = null;  
 }  
 removed = true;  
 }  
 else  
 {  
 Cell cCell = head;  
 while (cCell.Next != null && !removed)  
 {  
 if (cCell.Next.Data.Equals(value))  
 {  
 cCell.Next = cCell.Next.Next;  
 // We test if we reached the end of the list  
 if (cCell.Next != null)  
 {  
 cCell.Next.Previous = cCell;  
 }  
 else  
 {  
 // If we did, we update the tail.  
 tail = cCell;  
 }  
 removed = true;  
 }  
 else  
 {  
 // If we did not find the value,  
 // we move the cCell to the next  
 // cell to continue searching.  
 cCell = cCell.Next;  
 }  
 }  
 }  
 }  
 return removed;  
 }  
  
 public int Count  
 {  
 get  
 {  
 int size = 0;  
 Cell cCell = head;  
 while (cCell != null)  
 {  
 cCell = cCell.Next;  
 size++;  
 }  
 return size;  
 }  
 }  
  
 public bool IsReadOnly { get; set; }  
  
 public IEnumerator<T> GetEnumerator()  
 {  
 Cell cCell = head;  
 while (cCell != null)  
 {  
 yield return cCell.Data;  
 cCell = cCell.Next;  
 }  
 }  
  
 IEnumerator IEnumerable.GetEnumerator()  
 {  
 return this.GetEnumerator(); // call the generic version of the method  
 }  
  
 /\* We are done realizing the ICollection class. \*/  
  
 public override string ToString()  
 {  
 string returned = "———";  
 // Line above the table  
 for (int i = 0; i < Count; i++)  
 {  
 returned += "————";  
 }  
 returned += "\n| ";  
 // Content of the CList  
 Cell cCell = head;  
 while (cCell != null)  
 {  
 returned += $"{cCell.Data} | ";  
 cCell = cCell.Next;  
 }  
 returned += "\n———";  
 // Line below the table  
 for (int i = 0; i < Count; i++)  
 {  
 returned += "————";  
 }  
  
 // We go through the list in the other direction:  
  
 returned += "\n———";  
 // Line above the table  
 for (int i = 0; i < Count; i++)  
 {  
 returned += "————";  
 }  
 returned += "\n| ";  
 // Content of the CList  
 cCell = tail;  
 while (cCell != null)  
 {  
 returned += $"{cCell.Data} | ";  
 cCell = cCell.Previous;  
 }  
 returned += "\n———";  
 // Line below the table  
 for (int i = 0; i < Count; i++)  
 {  
 returned += "————";  
 }  
  
 if (Count > 0)  
 {  
 returned += $"\nHead: {head.Data}\n";  
 returned += $"Tail: {tail.Data}\n";  
 }  
 return returned;  
 }  
  
 public void RemoveF()  
 {  
 if (head != null)  
 {  
 if (head.Next != null)  
 {  
 head.Next.Previous = null;  
 }  
 head = head.Next;  
 }  
 }  
  
 public void RemoveL()  
 {  
 if (tail != null)  
 {  
 if (tail.Previous != null)  
 {  
 tail.Previous.Next = null;  
 }  
 tail = tail.Previous;  
 }  
 }  
  
 // Method to remove the nth element if it exists.  
 public void RemoveI(int index)  
 {  
 if (index > Count || index < 0)  
 {  
 throw new IndexOutOfRangeException();  
 }  
 else // Some IDE will flag this "else" as redundant.  
 {  
 if (index == 0)  
 {  
 RemoveF();  
 }  
 else if (index == (Count - 1))  
 {  
 RemoveL();  
 }  
 else  
 {  
 int counter = 0;  
 Cell cCell = head;  
 while (counter < index - 1)  
 {  
 cCell = cCell.Next;  
 counter++;  
 }  
 cCell.Next = cCell.Next.Next;  
 cCell.Next.Previous = cCell;  
 }  
 }  
 }  
}

[*(Download this code)*](https:/princomp.github.io/code/projects/DLList_ICollection.zip)

The main differences with *singly* linked list are as follows:

* Instead of keeping only track of the first element (first), we keep track of both the first (head) and last (tail) elements.
* Each Cell contains a pointer to the “next” element (as before), but also to the “previous” element.
* Adding (or removing) to the right is now done in constant time, instead of linear time.
* Traversing the list in opposite order (from end to beginning, or right to left) is now straightforward (cf. the ToString method above).
* The rest of the edits are about bookkeeping the Previous and Next attributes of the Cell, as well as updating the tail attribute. This makes removing and adding “in the middle of the list” a bit tricky.